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A food system optimization model Analysis

Siqi Jiang, Yongqi Cui

Anhui University of Science & Technology, Huainan, Anhui, 232001

Abstract: *The optimization of food system is studied in this paper. Today's food system, while highly efficient and profitable, is generally unstable, and this instability is reflected in equity and sustainability. In our understanding, to achieve fairness, it is necessary to eliminate monopoly, distribution according to demand, production according to demand and safe reserve; Sustainability is mainly for the protection of water resources and natural environment resources. In order to evaluate the security of the food system, we set up the food system security evaluation system. First, identify the internal factors that affect the security of the food system, that is, whether the yield and nutritional structure of agricultural and livestock products in a given country can meet the needs of its people. Establish, a multivariate nonlinear regression model according to the linear relationship between various nutrients and food security. Then, the external factors affecting the security of the food system and the influences of natural and social environment on the food system were identified. The index system is established, namely, the safety index sequence of each indicator is obtained, and the influence degree of external factors is given. Finally, combining with the weight ratio of external and internal causes, the food system security evaluation system is obtained.*

Keywords: *Analysis of coupling coordination, Markov theory, logit*

1. Introduction

The issue of food loss and waste around the world has received a lot of attention recently. Globally, nearly one-third of the food produced for human consumption is lost or wasted. Affected by multiple factors, there has been a serious loss and waste in food storage, transportation, processing [1], consumption and other links after delivery, and the utilization efficiency of food resources is not high. Therefore, reducing food loss and waste is an urgent task in the current process of strengthening food security and reducing the environmental impact of the food system.

2. The establishment and solution of the model

2.1 Establishing a food system security evaluation system

The food system is not only about the cultivation and distribution of food, but also about the level of agricultural technology, the purchasing power of residents, the quality of food, political and socio-economic stability [2]. In order to better reveal the global food security problems, it is necessary to analyze the influencing factors of food security pattern on the basis of systematic evaluation. In this paper, the factors affecting food system security are divided into internal and external factors. The internal factor includes the index value of all kinds of human essential nutrients, while the external factor includes the external factors such as environment, political and economic stability [3].

2.2 Selection of influencing factors

Internal cause: Stepwise regression analysis was conducted with FSI as the dependent variable and influencing factors of food security as the independent variable, and the entry standard was set as 0.05 of significance F-test probability.0.10 Influencing factors were screened as deletion criteria, and multiple linear regression equations were established as controls [4].

External cause: Under the premise of adequate food supply, the optimal state of the food system is finally achieved by obtaining food and fully, rationally and effectively utilizing its nutrients. Therefore, food access and food use are the ultimate way to optimize the food system [5].

3. Constructing internal cause evaluation system

(1) Linear variable substitution. It is realized mainly by single variable curve estimation and transformation variable assignment. Firstly, the univariate curve estimation was carried out. In SPSS20.0, FSI was taken as the dependent variable to perform curve estimation for the influencing factors screened in the previous step. During operation, all nonlinear models were selected in the model options, and the maximum determination coefficient R2 was selected to determine the optimal curve estimation equation. Second, the conversion variable is assigned. Substituting the values of standardized influencing factors into the optimal curve estimation equation, the simulated value of food security under the linear action of single factor, $Y_{ij}(i=1,2,...,133; j=1,2,...,m;)$, was introduced into the transformation variable T, and the simulated value was assigned to T. In this way, the transformation variable T was in $Y_{ij}(i=1,2,...,133; j=1,2,...,m;)$ linear relationship with FSI, and the coefficient of T could be further determined through multiple linear regression.

(2) Establish multiple linear regression equations. Firstly, the food security index FSI was taken as the dependent variable, and the transformation variable T was taken as the independent variable. The "entry" method was used to carry out multiple linear regression again to determine the coefficients of each transformation variable T and establish the transformation equations. Then the expression of the transformation variable T (Curve estimation equation) is substituted into the transformation equations to obtain the multiple linear regression equations. The multivariate linear regression equations were used to analyze the influencing factors according to the goodness-of-fit and significance test results. The general form of multiple linear regression model is as follows:

$$Y_i = \beta_0 + \beta_1 X_{1i} + ... + \beta_k X_{ki} + u_i (i=1,2,3,...n) \tag{1}$$

Where Y_i is the dependent variable, X_{1i} is the independent variable, β is the regression coefficient, and u_i is the random error term.

The general form of sample regression equation is:

$$\hat{Y}_i = \hat{\beta}_0 + \hat{\beta}_1 X_{1i} + \hat{\beta}_2 X_{2i} + ... + \hat{\beta} X_{ki} \tag{2}$$

Where $\hat{Y}_i$ is the sample conditional mean of the explanatory variable, and $\hat{\beta}$ is the estimate of the population parameter β.Maximum likelihood estimation method and least square estimation method are generally used to estimate the parameters of regression model.

4. Indicators in multiple linear regression analysis

4.1 Index

(1) The complex correlation coefficient R

R denotes the degree of close linear relationship between independent variable X_i and dependent variable Y_i; Values range from 0 to 1. The larger R value, the stronger the linear relationship.

(2) Determination coefficient of R^2 and correction determination coefficient $\bar{R}^2$

R^2 refers to the multiple determination coefficient, which is the coefficient to determine the degree of explanation of all explanatory variables to the explained variables in the multiple linear regression model. The value of R^2 ranges from 0 to 1, and the closer its value is to 1, it indicates that the sample data fit the selected linear regression model well.

(3) Zero-order correlation coefficient, partial correlation coefficient, partial correlation coefficient, etc.

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Table 1: Principal component analysis - variance contribution rate

The principal components	The eigenvalue	Differential eigenvalue	Variance contribution rate	Cumulative variance contribution rate
The principal components 1	3.31569	1.54945	0.3459	0.3459
The principal components 2	2.57893	1.26499	0.1857	0.5942
The principal components 3	1.42388	0.95496	0.1156	0.6649
The principal components 4	0.54883	0.79542	0.0265	0.7597
The principal components 5	0.12364	0.23548	0.0098	0.9846
The principal components 6	0.02846	0.04952	0.0042	1.0000

It shows the eigenvalues, variance contributions of the RTH principal component and cumulative variance contributions of the first r principal components obtained from the principal component analysis of the six indicators.

4.2 Data standardization processing

The index data is standardized by range standardization method.

(1) For the positive indicators:

$$X'_{ij} = (X_{ij} - \min X_{ij}) / (\max X_{ij} - \min X_{ij}) \tag{3}$$

(2) For negative indicators:

$$X'_{ij} = (\max X_{ij} - X_{ij}) / (\max X_{ij} - \min X_{ij}),\quad i = 1, 2, \ldots, 172;\ j = 1, 2, \ldots, 12 \tag{4}$$

Among them, X_{ij} is the original data of item j of the ith country; X'_{ij} is the corresponding standardized variable value, and $X'_{ij} \in [0,1]; \max(X_{ij}), \min(X_{ij})$ is the maximum and minimum value of the JTH index respectively.

4.3 Weight determination based on mean square deviation

The weights of internal and external causes can be considered equal.Since the influence of various nutrients on human health can be regarded as equal, the weight of each element in the internal cause set can be regarded as the same, so only the weight of the internal factors in the external cause set can be calculated.

Since the purpose of food security evaluation in this paper is to analyze the difference pattern of food security at the national level, the determined index weight should be able to reflect the relative dispersion degree of the value of each index sample.

For this reason, the mean square error method is used to determine the weight of each index. The steps are as follows.

(1) Based on standardized data set, the mean square deviation (standard deviation) of each evaluation index was calculated:

$$\partial = \sqrt{\frac{\sum_{i=1}^{n} (X'_{ij} - \bar{X}'_{ij})^2}{n}} \tag{5}$$

Where, ∂ represents the mean square deviation of indicators; X'_{ij} is the stand-ardized variable value of j index in the ith country; $\bar{X}'_{ij}$ is the mean value of the standardized variable; N is the number of participating countries.

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(2) Based on the mean square error, the weight coefficients of the three indexes of food supply, food access, food use, and economic and political stability were calculated respectively:

$$\omega_{mkj} = \frac{\partial_{mkj}}{\sum_{k=1}^{K} \partial_{mkj}} \tag{6}$$

In the formula, m represents the serial number of the year, m = 2000, 2001..., 2014;K is the number of three-level indexes including food supply, food access, food use, and economic and political stability, k is 4, 2, 3, 3;J represents the serial number of the three-level index, j = 1, 2..., 12; ω_{mkj} represents the weight of the index of item j in year m under the corresponding index of the next level.

(3) Calculate the mean weight coefficient of all three levels of indicators from 2000 to 2014, and take this as the unified weight of all three levels of indicators during the research period:

$$\omega_j = \sum_{m=2000}^{2014} \omega_{mkj} / 15, k = 4, 2, 3, 3; j = 1, 2, ..., 12 \tag{7}$$

4.4 Test of multivariate nonlinear regression analysis

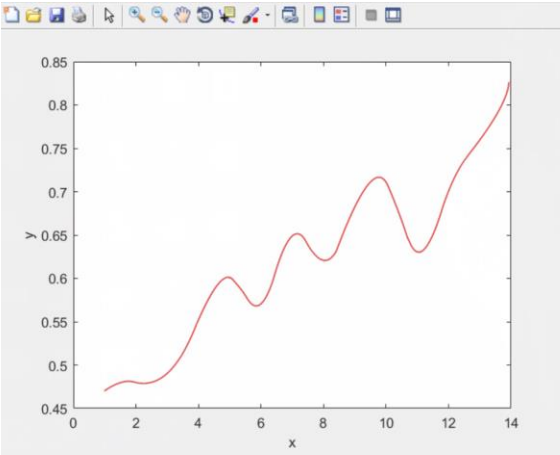

Figure 1: Clustering effectiveness growth curve

Based on the comprehensive evaluation, the average value of FSI natural discontinuous point was used as the unified grading standard, and the evaluation results were divided into five grades: extremely unsafe (0≤FSI≤0.51), unsafe (0.52≤FSI≤0.67), ordinary (0.68≤FSI≤0.84), relatively safe (0.85≤FSI≤1.11) and safe (1.12≤FSI≤2).The Silhouette Coefficient is used to test the clustering effectiveness of FSI, and the Silhouette Coefficient of all years is greater than 0.60, indicating that the unified classification standard is scientific and reasonable.

5. Conslusions

This model analyzes the factors that affect the food system, finds out the key factors, and then sorts the priority supply order of the food system, and then predicts the food safety coefficient through the time prediction model. The obtained food safety coefficient is relatively accurate. The model has a wide range of applicability. Different regions need to consider other factors (such as residents' eating habits, etc.) as covariates, which have a wide range of applications.

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